CREATIVE WATERSHED PERFORMANCE REQUIREMENTS FOR NEW DEVELOPMENT

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Abstract. Gwinnett County's Watershed Protection Plan represents the culmination of a two-year watershed assessment and modeling project. One key component of the watershed protection plan is the development and implementation of requirements for new development in the watershed.

In areas where water quality criteria provide little practical guidance for developing watershed protection plans, statistical relationships between biotic integrity (benthos, fish, and habitat scores) and pollutant loadings for key parameters in kg/ha/yr (lb/ac/yr) were used to develop watershed improvement guidelines. An automated spreadsheet analysis tool (WISE) was used to facilitate this analysis and allow interactive evaluation with the County and citizens' group.

Performance based strategies were used to provide needed protection as well as maximum flexibility for the development community. A site specific improvement guideline for TSS was developed and a spreadsheet tool that assists with new development layout to meet the target was developed. Options are provided for implementing BMPs on the site and designating the tributary drainage area to each BMP. The form automatically graphs and compares the uncontrolled and controlled loading rates to the performance criterion. This tool can be used iteratively in the site design process.

In addition to the new development tool which focuses mainly on water quality controls, Gwinnett's regulations were also revised to control water quantity from new developments including four key hydrologic design events, 1) major flooding (100 year events), 2) out of bank flooding (10 to 25-year events), 3) channel protection (1-year events) and 4) water quality protection (1.2 inch rainfall). These design events are managed to protect the environment and the public. In combination with the BMP form, these strategies provide needed protection to streams as well as maximum flexibility for the development community.

INTRODUCTION

Gwinnett County, like many suburban areas near Atlanta, is experiencing rapid population growth and corresponding changes in land use. These changes dramatically affect the character of many of the County's watersheds. The State of Georgia recently began requiring watershed assessments, and corresponding watershed protection plans, to help mitigate the secondary impacts of development on the health of its lakes and streams.

In early 1998, the Gwinnett County Department of Public Utilities (DPU) began a comprehensive watershed assessment project covering all 437 square miles of the county. The project's major components are watershed characterization (including habitat, benthos, fish, and water quality monitoring), watershed modeling (using BASINS), watershed protection, and public involvement. Currently all tasks in the project are complete.

METHODOLOGY

The project included an integrated assessment of the habitat, the biological community, water quality, and pollutant loadings in the streams; the assessment was used to evaluate impacts on the streams and their uses. The integrated assessment of these impacts is the key to developing an effective, efficient watershed protection and improvement strategy.

Project Methodology

The Gwinnett County project built on earlier work in the region (such as Hall and Richards, 1998). In particular, it refined the modeling approaches (using BASINS) and the tools for evaluating relationships among habitat, pollutant loading rates, and biotic integrity. The integrated assessment was used to determine the impacts on the streams and their uses (CH2M HILL, 2000a). The assessment confirmed results from other studies that uncontrolled imperviousness in watersheds significantly degrades

aquatic integrity (Schueler, 1994). This information was used as the basis for the watershed protection plan.

Watershed Protection Methodology

There are three basic strategies available in watershed protection: voluntary, prescriptive, and performance-based. Because performance-based strategies provide needed protection as well as maximum flexibility for the development community, the focus of Gwinnett County's strategy is performance-based.

One benchmark that was used for the Gwinnett County watersheds is the attainment of water quality standards. Water quality standards are defined as the combination of a designated use (e.g., fishing) and a criterion to protect that use (e.g., 5 mg/L dissolved oxygen). In most cases, the study indicated that the streams are meeting the criteria associated with the water quality standards. However, the aquatic life of a stream or waterbody is affected by all of the contributing stressors, including those during storm events that occur sporadically, are difficult to measure physically and chemically, and often produce significant degradation. This is common to many streams across the nation, and is traditionally a difficult problem to address.

Therefore, we focused our on protection of the designated use. The benthic macroinvertebrate (aquatic insects), fish, and habitat results of the study provide a comprehensive assessment of watersheds in the county. As an example, if the results indicate "good" biotic integrity for benthic macroinvertebrates (the scale ranges from very good to very poor), then the use is being protected.

The results of the characterization study indicated that the biological life and habitat in streams, as measured by fish, benthic macroinvertebrate, and habitat indices, is correlated with the total annual load of certain pollutants contributed to the stream. This pollutant load (or total number of pounds), when divided by the contributing drainage area, provides a measure of both the volume of storm water runoff generated annually as well as the amount of pollution that it carries.

The County worked closely with a stakeholder Citizens' Advisory Group (CAG) throughout the entire project. The CAG reviewed deliverables, received real-time project updates, and developed recommendations for the staff to consider and present to the County Commissioners. This approach allowed the stakeholder committee for the project to develop tangible, "living" goals for its streams and watersheds. The watershed protection strategy was developed to meet the aquatic integrity goals.

Benthos were selected as the representative indicator for biotic integrity in developing the watershed goals. Fish were not used because of the smaller data set. The CAG and DPU concurred that the goal for the County's watersheds should be the "Good" range for the benthic macroinvertebrate index such that the designated use for the stream is being met. There was considerable discussion about whether the goal should be the upper or lower portion of the "Good" range. However, there was agreement and recognition that the benthic score for a watershed should remain a goal, and that in some existing heavily developed watersheds, this goal might not be attainable. On the other hand, watersheds with benthic scores higher than the goal would often be protected in order to remain well within the goal and thereby ensure protection of water quality.

Total suspended solids (TSS) is a key pollutant associated with sediment. It also serves as a "carrier" of other pollutants such as organics, nutrients, and metals, and is often used as a key parameter for sizing BMPs for protecting water quality. Therefore, control of TSS was used as a surrogate for the most important pollutants which need to be controlled to meet the designated use and water quality standards in the stream.

An automated spreadsheet analysis tool (WISE) was developed to facilitate this analysis and allow it to be interactive with the County and CAG. The correlations analysis was organized and automated in a spreadsheet format with a user friendly interface. WISE allows the evaluation and comparison of numerous parameters via correlations, plots, and regressions. The parameters can be easily and quickly changed via object-linked menus. WISE was also used to evaluate the implications of revising biotic integrity targets, from the perspective of required pollutant load control, associated planning level cost, and additional parameters.

RESULTS

Watershed Assessment

The results of the Gwinnett County watershed assessment indicated evident habitat impacts in the streams. However, water quality, benthos, and fish monitoring show relatively good water quality and fair biotic integrity. In general, the watersheds were moderately impacted within the county, as demonstrated by "good" to "fair" benthos and fish scores in most areas. Water quality monitoring showed elevated fecal coliform levels during wet

weather consistent with both national and regional data, and corresponding also to the elevated levels measured at the unimpacted reference stations. Modeling results (using the BASINS modeling framework and detailed future land use coverages) coupled with correlations between pollutant loading rates and habitat, benthos, and fish scores, indicate that the biotic integrity in the watershed will degrade further if protective measures are not taken.

Watershed Protection

Working with the CAG, a benthos score of 18 (in the "Good" "range) was selected as the overall goal for the County watersheds. Therefore, subwatersheds below this level would be prioritized for improvement, and subwatersheds above this level would be targeted for protection. Using statistical relationships, this benthos score was correlated with an annual pollutant loading of 1,600 pounds per acre per year (using the BASINS loading estimates). Note that this guideline includes not only direct washoff of TSS from developed sites, but also TSS load from the bed of streams due to changed hydrology and increased flow (a consequence of additional impervious surface) in the watershed.

This guideline is an aggregate value for a watershed, and includes undeveloped areas, developing areas, and developed areas. The previously developed areas are not affected by new development requirements, except for the relatively small portion that is redeveloped in any year. Also, undeveloped areas that are projected to be developed under the 20-year comprehensive plan include state roads, bridges, and many other facilities and developments that would likely not be fully covered under the new development requirements. For new development to fulfill the objective of "reduce impacts" to protect and preserve water quality, the performance criterion for new development must be set well below the aggregate guideline for watersheds in the county, and closer to the estimated load from an undeveloped or sparsely developed site (between 500 and 600 lb/ac/yr). Examples of the future (2020) total load from selected watersheds assuming a range of performance requirements for new development are shown in Table 1, along with the tool used to interactively discuss this information with the CAG.

DEVELOPMENT REVIEW PROTOCOL AND TOOLS

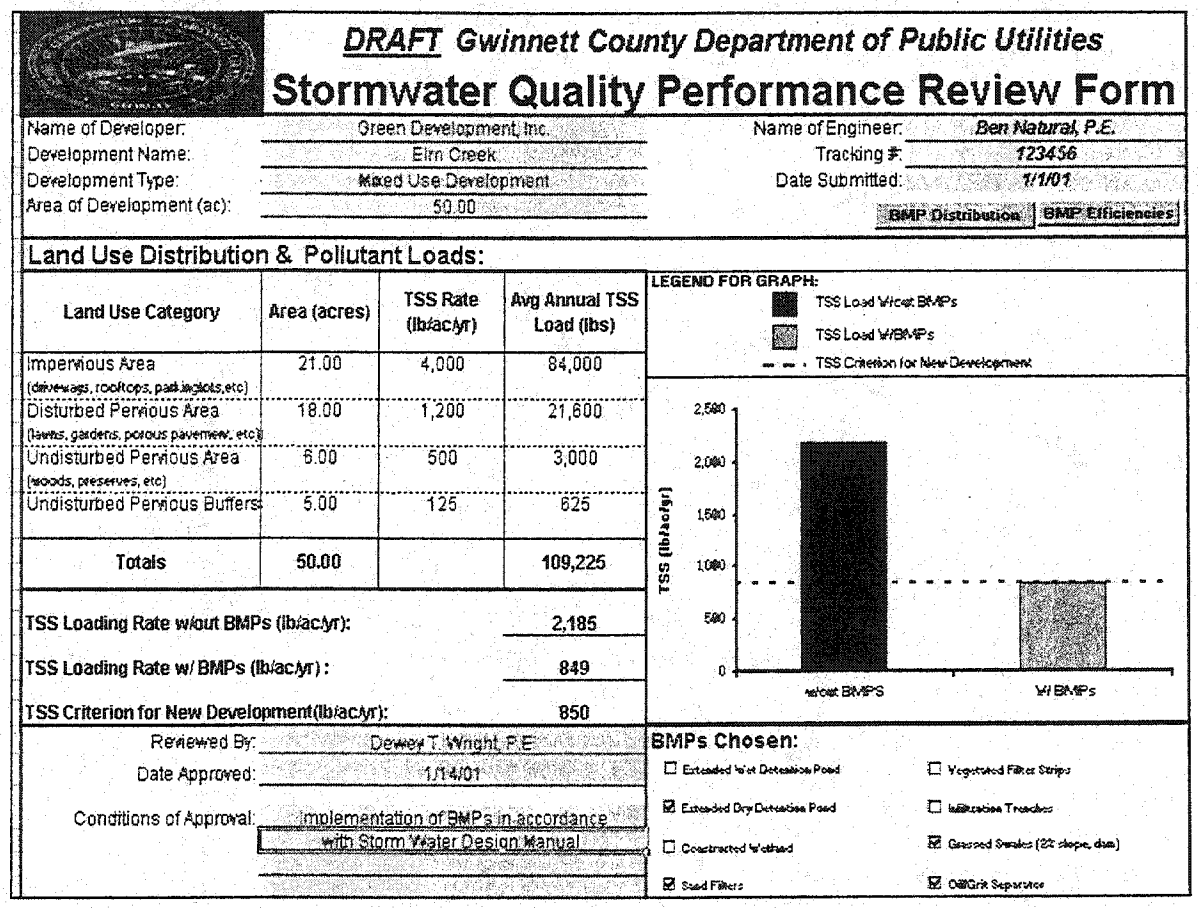
The project team developed a spreadsheet tool to facilitate evaluation of developments in accordance with TSS performance criteria (Figure 1). The tool was developed with the strategy of providing disincentives for installation of impervious surfaces, and incentives for maximizing undisturbed areas and stream buffers.

The review protocol categorizes four distinct types of land area on each site:

- Impervious Area – e.g., driveways, rooftops, parking lots, roads, sidewalks, etc.
- Disturbed Pervious Area – e.g., lawns, gardens, landscaped areas, any area that was cleared, grubbed, and graded
- Undisturbed Pervious Area – e.g., upland woods, meadows, and other areas not cleared, grubbed, and graded
- Undisturbed Pervious Stream Buffers – e.g., riparian buffers contiguous to streams, lakes, and wetlands.

Table 1. Projected 2020 Watershed TSS Loads Under Various New Development Criteria

New Development Criteria (lb/ac/yr)	Total 2020 Watershed TSS Load (lb/ac/yr) (Assuming That New Development Meets Criteria at Left)			
	Suwanee Creek	Richland Creek	Alcovy River	Crooked Creek
600	1,500	1,770	1,530	2,470
850	1,570	1,840	1,590	2,510
1,000	1,610	1,880	1,630	2,530
1,200	1,670	1,940	1,680	2,560



DRAFT Gwinnett County Department of Public Utilities

Stormwater Quality Performance Review Form

Name of Developer:	Green Development, Inc.	Name of Engineer:	Ben Natural, P.E.
Development Name:	Elm Creek	Tracking #:	123456
Development Type:	Mixed Use Development	Date Submitted:	1/1/01
Area of Development (ac):	50.00		

BMP Distribution | BMP Efficiencies

Land Use Distribution & Pollutant Loads:

Land Use Category	Area (acres)	TSS Rate (lb/ac/yr)	Avg Annual TSS Load (lbs)
Impervious Area (driveways, rooftops, parking lots, etc)	21.00	4,000	84,000
Disturbed Pervious Area (lawns, gardens, porous pavement, etc)	18.00	1,200	21,600
Undisturbed Pervious Area (woods, preserves, etc)	6.00	500	3,000
Undisturbed Pervious Buffers	5.00	125	625
Totals	**50.00**		**109,225**

TSS Loading Rate w/out BMPs (lb/ac/yr):	2,185
TSS Loading Rate w/ BMPs (lb/ac/yr):	849
TSS Criterion for New Development (lb/ac/yr):	850

LEGEND FOR GRAPH: TSS Load W/out BMPs; TSS Load W/BMPs; TSS Criterion for New Development

Reviewed By: Dewey T. Wright, P.E.

Date Approved: 1/14/01

Conditions of Approval: Implementation of BMPs in accordance with Storm Water Design Manual

BMPs Chosen:

- ☐ Extended Wet Detention Pond
- ☑ Extended Dry Detention Pond
- ☐ Constructed Wetland
- ☑ Sand Filters
- ☐ Vegetated Filter Strips
- ☐ Infiltration Trenches
- ☑ Grassed Swales (2% slope, dia)
- ☑ Oil/Grit Separator

Figure 1. Storm Water Quality Performance Review Form.

A TSS loading rate is assigned to each area commensurate with its potential contribution to aggregate loading to the watershed (Figure 2). Undisturbed areas are assigned lower loading rates reflecting their potential for lower loadings and pollutant removal as vegetated filter strips for adjacent areas.

The sum of the products of the areas and their corresponding TSS loading rates represent the total uncontrolled load from the site. The approach is simple to use and encourages site design that takes advantage of the natural site amenities and minimizes impervious surfaces. The computerized spreadsheet form automatically calculates and graphs this value, and provides options for implementing BMPs on the site and designating the tributary drainage area to each BMP. The forms allow the developer to select from a menu of 8 different BMPs as a part of the site design. The form compares the uncontrolled and controlled loading rates to the TSS criterion. This tool can be used iteratively in the site design process to determine the right combination of BMPs or site design layout that will meet the performance criteria.

An integral part of the effectiveness of the New Development Review Tool is the revised regulations for water quantity control with new development and the BMP design guidance provided in the Storm Water Design Manual (Gwinnett DPU, 2000). Gwinnett's regulations were revised to control water quantity from new developments to provide channel protection and water quality benefits for 1-year storm events. The revised regulations require that the one year storm will be detained for 24 hours, thus addressing volume, velocity, and hydrologic peaks from storm events that were previously uncontrolled. These design events are used to size storm water BMPs and serve to manage and protect the environment and the public.

The project team evaluated, and reviewed with the CAG, numerous actual sites that had been submitted for development review. Six residential sites and four commercial sites were initially evaluated using the development review form. Additional sites were added as the discussions ensued. Members of the CAG then evaluated over ten additional sites using the tool.

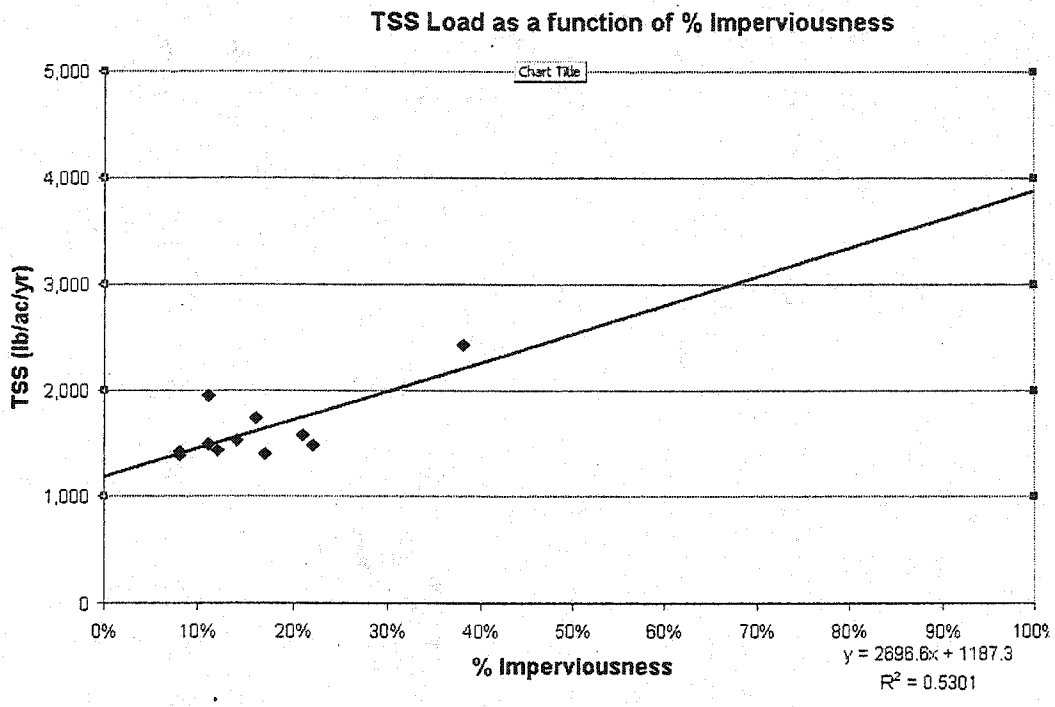


Figure 2. TSS load as a function of percent imperviousness.

New Development Performance Criterion

In creating a performance criterion for new development using this tool, a cost analysis was performed to represent the cost associated with various levels of pollutant load allowed to run off of the site. The cost analysis was performed for both residential and commercial land uses using actual developments submitted to the County for review. A series of curves was developed, showing cost per acre versus TSS load in pounds per acre per year.

The cost evaluation was performed to relate the level of control (i.e. the chosen BMPs) required on the site to the total cost of implementing water quality controls (Figure 3). Note that this cost is the cost beyond implementing absolutely no controls, not the cost beyond current requirements.

A comparison with the cost of existing requirements resulted in the following:

- Residential—Depending on the specific characteristics of the site and design, ranging from \$0/ac to \$1,000/ac, or 0 percent to 20 percent beyond current water quality BMP costs.
- Commercial—Depending on the specific characteristics of the site and design, ranging from \$0/ac to \$6,000/ac, or 0 percent to 30 percent beyond current water quality BMP costs.

Because for many subbasins there is a balance between requirements placed on new development and retrofitting existing development, a similar cost analysis was performed representing the retrofitting. The first component of the retrofit cost analysis produced a curve similar to that for new development. The second component characterized the cost of restoring streambanks and associated stream habitat in the developed portions of the county. Depending on the particular situation, the retrofit costs were 5 to 50 times higher than that for new development requirements.

Using this information, the CAG interactively evaluated the tradeoffs for varying levels of control for new and existing development. The CAG discussed a range for the New Development Performance Criterion from 600 lb/ac/yr to 1,100 lb/ac/yr based on the potential to prevent further significant degradation in the watersheds due to new development and considering the potential costs for implementing the criterion and retrofitting of existing development. The resulting DPU staff recommendation was 850 lb/ac/yr as a balance among these issues.

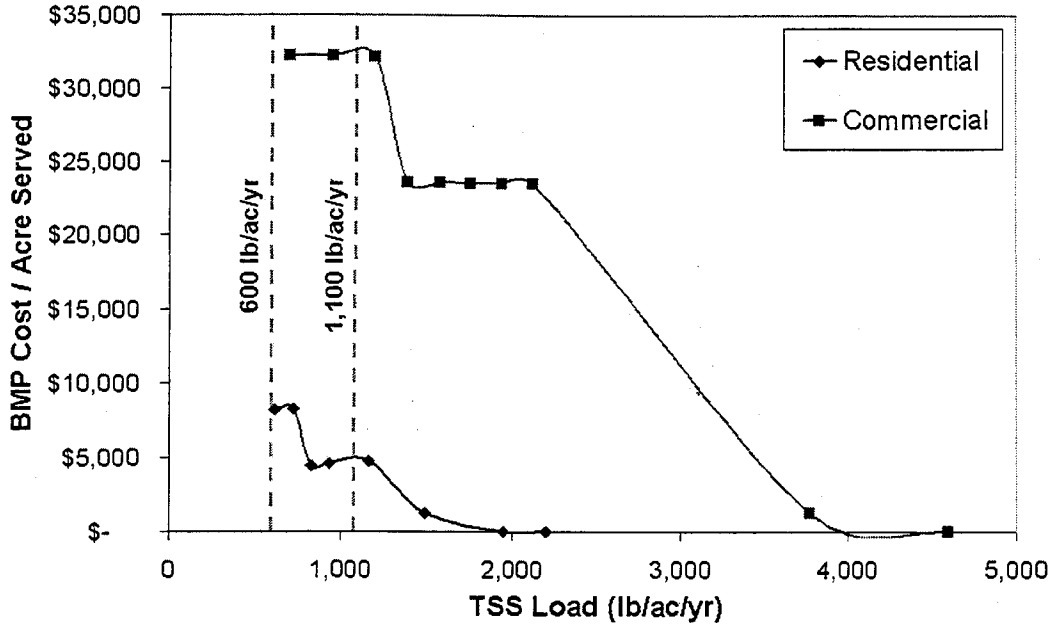


Figure 3. Total cost of implementing water quality controls.

CONCLUSIONS

In rapidly developing areas the key to successful watershed protection is the implementation of effective requirements for new development. However, these requirements are often difficult to implement because of opposition from the development community and those with vested interests in property rights. The approach presented in this paper focuses on performance-based development requirements. These requirements provide considerable flexibility to the development community while ensuring the necessary level of protection.

These performance-based requirements may take any of several forms. In most cases, the criterion components of water quality standards are not useful in developing watershed protection plans. Therefore, an alternative approach is to focus on protection of the designated use as measured by biotic indices. These indices can then be correlated to parameters useful in the development of site requirements for BMPs.

Interactive tools that support design and evaluation make the local government's job easier. They also provide the development community with a tool for efficient design and remove several layers of uncertainty in the development review process. These tools and approaches can be designed to encouraged desired characteristics in site design, such as minimization of impervious surfaces and protection of undisturbed stream buffers beyond minimum requirements.

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